



<http://dx.doi.org/10.11646/zootaxa.3948.1.1>

<http://zoobank.org/urn:lsid:zoobank.org:pub:B596920C-270F-48B3-98B3-3FDFBF184576>

An integrative taxonomic review of the agamid genus *Bronchocela* (Kuhl, 1820) from Peninsular Malaysia with descriptions of new montane and insular endemics

L. LEE GRISMER¹, P. L. WOOD, JR.², CHEOL HAENG LEE², EVAN S. H. QUAH³, SHAHRUL ANUAR³, EHWAN NGADI⁴ & JACK W. SITES, JR.²

¹Department of Biology La Sierra University, 4500 Riverwalk Parkway, Riverside, California, 92515 USA.
E-mail: lgrismer@lasierra.edu; mmur027@lasierra.edu

²Department of Biology, Brigham Young University, 150 East Bulldog Boulevard, Provo, Utah 84602 USA.
E-mail: perryleewoodjr@gmail.com, cheolhaeng@gmail.com, jack_sites@byu.edu

³School of Biological Sciences, Universiti Sains Malaysia, 11800 USM, Pulau Pinang, Penang, Malaysia.
E-mail: evanquah@yahoo.com, shahrulanuar@gmail.com

⁴Institute for Environment and Development, (LESTARI), Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor Darul Ehsan, Malaysia. E-mail: ehwanngadi@yahoo.com

Abstract

An integrative taxonomic analysis is used to identify and describe two new species of the agamid genus *Bronchocela* (Kuhl) from Peninsular Malaysia: an upland species *B. shenlong* sp. nov. from Bukit Larut, Perak in the Bintang Mountain Range and Parit Falls, Cameron Highlands, Pahang in the Titiwangsa Mountain Range and an insular species, *B. rayaensis* sp. nov., from Pulau Langkawi, Kedah off the northwest coast on the border with Thailand. Both species are diagnosed from each other and all other species of *Bronchocela* on the basis of body shape, scale morphology, and color pattern. The analysis also demonstrates the remarkable genetic similarity of *B. cristatella* (Kuhl) throughout 1120 km of its range from northern Peninsular Malaysia to western Borneo despite its highly variable coloration and pattern. The two new species are appended to a rapidly growing list of newly described lizard species (60 to date) from Peninsular Malaysia tallied within the last decade.

Key words: Peninsular Malaysia, Integrative taxonomy, *Bronchocela*, Langkawi Island

Introduction

The agamid genus *Bronchocela* (Kuhl) contains 10 species (Hallermann 2009) that collectively range from South Asia, southern Indochina and the Philippines, southward and eastward through the Thai-Malay Peninsula and the Indo-Australian Archipelago to at least western New Guinea (Manthey 2008). These are attractive, conspicuous, diurnal, arboreal lizards that inhabit open and disturbed areas ranging from sea level to over 1,600 meters and are often seen perched in open, sunlit areas as high as 30 meters above the ground on the trunks and branches of trees. Currently, only *B. cristatella* (Kuhl) is known from Peninsular Malaysia although its vast geographic range nearly encompasses that of the entire genus (Manthey 2008). Commensurate with this broad, fragmented distribution is a considerable degree of morphological and color pattern variation (see photos in Manthey [2008] and Grismer [2011]) yet only morphometric variation in Peninsular Malaysian populations has ever been studied (Diong & Lim 1998). Grismer (2011) noted that the upland population of *B. cristatella* from Bukit Larut, Perak in the Bintang Mountain Range was composed of lizards manifesting color pattern characteristics not reported in other populations of *B. cristatella* and suggested genetic analyses would be helpful in resolving the taxonomic nature of this population. We have recently discovered an unreported upland population of *Bronchocela* from Parit Falls, Cameron Highlands, Pahang in the adjacent Titiwangsa Mountain Range composed of lizards bearing the same unique color pattern characteristics as those from Bukit Larut. We also report here on two specimens of *B.*

Larut in their respective upland corridors is unknown. South of Cameron Highlands in the Titiwangsa Mountain Range, Grismer (2011) lists an unconfirmed report from *B. cristatella* from Fraser's Hill, Pahang (Fig. 1). A specimen confirmed as *B. cristatella* from even farther south at Genting Highlands (LSUHC 5097) taken at 885 meters was used in this analysis (Figs. 1,2).

Discussion

The deep, phylogenetic substructuring among the populations of *Bronchocela* from Peninsular Malaysia—albeit a very small section of the overall distribution of this genus—previously considered to be *B. cristatella*, underscores the existing taxonomic challenges that still face this group throughout the remainder of its vast range. It is all but certain as additional populations of *B. cristatella* from other regions are studied, many new species will be described.

The number of new species of lizards currently being discovered and described from Peninsular Malaysia and its associated islands exceeds that of any other nation in Southeast Asia despite the fact it is one of the smallest geopolitical regions in area (larger than only Singapore and Brunei). In the last decade alone, 60 new species (41% of the currently recognized lizard fauna) have been described—the bulk of which have been within the Gekkonidae (24 species of *Cyrtodactylus*, 22 species of *Cnemaspis*, and two species of *Hemiphyllodactylus*) with skinks (six species of *Sphenomorphus*, two species of *Larutia*, and one species of *Lipinia*), agamids (two species of *Acanthosaura*), and dibamids (one species of *Dibamus*) trailing far behind (contact LLG for a reference list and .pdfs of these descriptions). Additionally, we currently have 13 more species descriptions in various stages of completion. Although some of these descriptions resulted from field work being undertaken in previously unexplored areas, 75% (45 species) resulted from new collections made at previously known collecting sites. The point here is that Peninsular Malaysia does not exist in a vacuum and should stand as a clear and unmistakable message to other Southeast Asian nations that there is no reason to believe their unrealized herpetological diversity is any less extensive. Given the rate at which many of these nations are being deforested, taxonomy-driven field research is desperately needed.

Acknowledgments

This research was supported in part by a grant to LLG from the College of Arts and Sciences at La Sierra University. For the loan of specimens we thank K. K. P. Lim, P. K. L. Ng, H. H. Tan, and C. M. Yang (ZRC) from Lee Kong Chian Natural History Museum, National University of Singapore, Singapore.

References

- Darriba D., Taboada, G.L., Doallo, R. & Posada, D. (2012) "jModelTest 2: more models, new heuristics and parallel computing". *Nature Methods*, 9 (8), 772.
<http://dx.doi.org/10.1038/nmeth.2109>
- Diong, C.H. & Lim, S.S.L. (1998) Taxonomic review and morphometric description of *Bronchocela cristatella* (Kuhl, 1820) (Squamata: Agamidae) with notes on other species in the genus. *Raffles Bulletin of Zoology*, 46, 345–359.
- Drummond, A.J., Ashton, B., Buxton, S., Cheung, M., Cooper, A., Duran, C., Field, M., Heled, J., Kearse, M., Markowitz, S., Moir, R., Stones-Havas, S., Sturrock, S., Thierer, T. & Wilson, A. (2011) Geneious V5.6. Available from [Http://www.Geneious.Com/](http://www.Geneious.Com/) (accessed 16 March 2015)
- Grismer, L.L. (2008) A new species of insular skink (Genus *Sphenomorphus* Fitzinger 1843) from the Langkawi Archipelago, Kedah, West Malaysia with the first report of the herpetofauna of Pulau Singa Besar and an updated checklist of the herpetofauna of Pulau Langkawi. *Zootaxa*, 1691, 53–56.
- Grismer, L.L. (2011) *Lizards of Peninsular Malaysia, Singapore and Their Adjacent Archipelagos*. Edition Chimaira, Frankfurt am Main, 728 pp.
- Grismer, L.L., Chan, K.O., Grismer, J.L., Wood, P.L. Jr. & Norhayati, A. (2010) A checklist of the herpetofauna of the Banjaran Bintang, Peninsular Malaysia. *Russian Journal of Herpetology*, 17, 147–160.
- Grismer, L.L., Norhayati, A., Chan, K.O., Belabut, D., Muin, M.A., Wood, P.W. Jr. & Grismer, J.L. (2009) Two new diminutive species of *Cnemaspis* Strauch 1887 (Squamata: Gekkonidae) from Peninsular Malaysia. *Zootaxa*, 2019, 40–56.

- Grismer, L.L. & Quah, E.S.H. (2015) The Rediscovery of *Sphenomorphus malayanus* Doria, 1888 (Squamata: Scincidae) from the Titiwangsa Mountain Range of Peninsular Malaysia and its re-description as *S. senja* sp. nov. *Zootaxa*, 3931 (1), 63–70.
<http://dx.doi.org/10.11646/zootaxa.3931.1.4>
- Grismer, L.L., Wood, P.L. Jr., Quah, E.S.H., Shahrul, A., Muin, M.A. Sumontha, M., Norhayati, A., Bauer, A.M., Wangkulangkul, S., Grismer, J.L. & Pauwels, O.S.G. (2012) A phylogeny and taxonomy of the Thai-Malay Peninsula Bent-toed Geckos of the *Cyrtodactylus pulchellus* complex (Squamata: Gekkonidae): combined morphological and molecular analyses with descriptions of seven new species. *Zootaxa*, 3520, 1–55.
- Grismer, L.L., Wood, P.L. Jr., Shahrul, A., Riyanto, A., Norhayati, A., Muin, M.A., Sumontha, M., Grismer, J.L., Chan, K.O., Quah, E.S.H. & Pauwels, O.S.G. (2014) Systematics and natural history of Southeast Asian Rock Geckos (genus *Cnemaspis* Strauch, 1887) with descriptions of eight new species from Malaysia, Thailand, and Indonesia. *Zootaxa*, 3880 (1), 1–147.
<http://dx.doi.org/10.11646/zootaxa.3880.1.1>
- Grismer, L.L., Youmans, T.M., Wood, P.L.Jr., Ponce, A., Wright, S.B., Jones, B.S., Johnson, R., Sanders, K.L., Gower, D.J., Norsham, S.Y. & Lim, K.K.P. (2006) Checklist of the herpetofauna of Pulau Langkawi, Malaysia, with comments on taxonomy. *Hamadryad*, 30 (1&2), 61–74.
- Hallermann, J. (2004) A new species of the genus *Bronchocela* from the tropical rain forest of southern Vietnam. *Russian Journal of Herpetology*, 11, 30–34.
- Hallermann, J. (2005) A taxonomic review of the genus *Bronchocela* (Squamata: Agamidae) with description of a new species from Vietnam. *Russian Journal of Herpetology*, 12, 167–182.
- Hallermann, J. (2009) A new species of *Bronchocela* (Squamata: Agamidae) from Nicobar Island. *Bonner zoologische Beiträge*, 56, 279–284.
- Kuhl, H. (1820) Beiträge zur Kenntnis der Amphibien. In: Kuhl (Ed.), *Beiträge zur Zoologie und Vergleichenden Anatomie*. Hermannsche Buchhandlung, Frankfurt am Main, pp. 75–132.
- Lim, B.L., Noor, A.W.O., Chan, K.O., Belabut, D. & Norhayati, A. (2009) An updated checklist of the herpetofauna of Pulau Singa Besar, Langkawi, Peninsular Malaysia. *Malaysian Applied Biology*, 39, 13–33.
- Macey, J. & Schulte, J. (1999) Molecular Phylogenetics, Trna Evolution, and Historical Biogeography in Anguid Lizards and Related Taxonomic Families. *Molecular Phylogenetics and Evolution*, 12, 250–272.
<http://dx.doi.org/10.1006/mpev.1999.0615>
- Maddison, D.R. & Maddison, W.P. (2005) MacClade 4: Analysis of Phylogeny and Character Evolution. Version 4.08a. Available from: <http://Macclade.Org> (accessed 16 March 2015)
- Manthey, U. (2008) *Agamid lizards of Southern Asia, Draconinae 1. Terralog 7*. Edition Chimaira, Frankfurt am Main, 160 pp.
- Pyron, R.A., Burbrink, F.T. & Wiens, J.J. (2013) A phylogeny and revised classification of Squamata, including 4161 species of lizards and snakes. *BMC evolutionary biology*, 13 (1), 93.
<http://dx.doi.org/10.1186/1471-2148-13-93>
- Ronquist, F., Teslenko, M., van der Mark, P., Ayres, D.L., Darling, A., Höhna, S., Larget, B., Liu, L., Suchard, M.A., Huelsenbeck, J.P. (2012) MrBayes 3.2: Efficient Bayesian phylogenetic inference and model choice across a large model space. *Systematic Biology*, 61, 539–542.
<http://dx.doi.org/10.1093/sysbio/sys029>
- Sabaj-Pérez, M.H. (Ed.) (2014) Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an Online Reference. Version 5.0. American Society of Ichthyologists and Herpetologists, Washington, DC. Electronically accessible. Available from: <http://www.asih.org/> (accessed 22 September 2014)
- Stamatakis, A. (2008) Raxml-Vi-Hpc: maximum likelihood-based phylogenetic analyses with thousands of taxa and mixed models. *Bioinformatics(Oxford)*, 22, 2688–2690.
<http://dx.doi.org/10.1093/bioinformatics/btl446>
- Tamura, K., Peterson, D., Peterson, N., Stecher, G., Nei, M. & Kumar, S. (2011) MEGA5: Molecular Evolutionary Genetics Analysis using Maximum Likelihood, Evolutionary Distance, and Maximum Parsimony Methods. *Molecular Biology and Evolution*, 28, 2731–2739. <http://dx.doi.org/10.1093/molbev/msr121>
- Wilcox, T.P., Zwickl, D.J., Heath, T.A. & Hillis, D.M. (2002) Phylogenetic relationships of the Dwarf Boas and a comparison of Bayesian and bootstrap measures of phylogenetic support. *Molecular Phylogenetics and Evolution*, 25, 361–371.
[http://dx.doi.org/10.1016/S1055-7903\(02\)00244-0](http://dx.doi.org/10.1016/S1055-7903(02)00244-0)
- Zimmerer, J. (2004) *Nature Guide, Langkawi*. Sakti Mega Enterprise, Malaysia, 184 pp.

APPENDIX

The following is a list of specimens examined in this study.

Bronchocela cristatella—Malaysia: Johor: Bunker Trail ZRC 2.4993; Endau-Rompin LSUHC 7678, 7711, 8121, 8235; Gunung Ledang LSUHC 10581, ZRC 2.5435; Pulau Babi Besar LSUHC 5568; Pulau Pemanggil LSUHC 4467, 8022; Pulau Pisang ZRC 2.5997–98, 2.343–48, 2.493–97. Pulau Sibul LSUHC 5526, 6394, 5777; Pulau Sibul Tengah LSUHC 5807; Pulau Tulai 4689–90, 6276. Kedah: Pulau Langkawi LSUHC 7535; Pulau Singa Besar DWNP 2250, 2997; Ulu Muda DWNP 459,

5106, LSUHC 12047. Negeri Sembilan: Pasoh DWNP 4939. Pahang: 12 km S Parit Fall, Cameron Highlands LSUHC 12103; Lakum Forest Reserve DWNP 2276; Pulau Tioman LSUHC 3974–75, 4613, 5412; Pulau Kuala Teku ZRC 2.338–40. Perak: Gerik ZRC 2.6264; Sungai Enam, Belum LSUHC 12061, Pulau Banding LSUHC 12056, Pulau Jarak ZRC 2.5996; Taiping LSUHC 12102, Tapah ZRC 2.4815–18; Temengor Forest Reserve LSUHC 5673. Penang: Bukit Mertajam LSUHC 12048, Pulau Pinang LSUHC 6742, 10647, 11804. Selangor: Ampang Reservoir LSUHC 6660–61; Ulu Gombok LSUHC 3515; Kuala Selangor Nature Park LSUHC 6543–44; Genting Highlands LSUHC 5097. Terengganu: Hutan Lipur Sekayu LSUHC 11992; Pulau Bidong LSUHC 11423; Pulau Lang Tengah LSUHC 11878; 11901–02; Pulau Redang LSUHC 9390. Singapore: Pulau Ubin ZRC 2.357–69.